the reference flow rates used to meet the C_d versus $Re^{\#}$ equation's regression criteria.

(e) *CFV calibration.* Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. For CFV flow meters that consist of multiple venturis, either calibrate each venturi independently to determine a separate discharge coefficient, C_d, for each venturi, or calibrate each combination of venturis as one venturi. In the case where you calibrate a combination of venturis, use the sum of the active venturi throat areas as A_t, the square root of the sum of the squares of the active venturi throat diameters as d_t, and the ratio of the venturi throat to inlet diameters as the ratio of the square root of the sum of the active venturi throat diameters (d_t) to the diameter of the common entrance to all of the venturis (D). To determine the C_d for a single venturi or a single combination of venturis, perform the following steps:

(1) Use the data collected at each calibration set point to calculate an individual C_d for each point using Eq. 1065.640–4.

(2) Calculate the mean and standard deviation of all the C_d values according to Eqs. 1065.602–1 and 1065.602–2.

(3) If the standard deviation of all the C_d values is less than or equal to 0.3% of the mean $C_{d,}$ use the mean C_d in Eq 1065.642–6, and use the CFV only up to the highest r measured during calibration using the following equation:

$$r = 1 - \frac{\Delta p_{CFV}}{p_{in}}$$

Eq. 1065.640-13

Where:

$\Delta p_{\_\_CFV}$ = Differential static pressure; venturi inlet minus venturi outlet.

(4) If the standard deviation of all the C_d values exceeds 0.3% of the mean $C_{d,}$ omit the C_d values corresponding to the data point collected at the highest r measured during calibration.

(5) If the number of remaining data points is less than seven, take corrective action by checking your calibration data or repeating the calibration process. If you repeat the calibration process, we recommend checking for leaks, applying tighter tolerances to measurements and allowing more time for flows to stabilize.

(6) If the number of remaining C_d values is seven or greater, recalculate the mean and standard deviation of the remaining C_d values.

(7) If the standard deviation of the remaining C_d values is less than or equal to 0.3% of the mean of the remaining $C_{d,}$ use that mean C_d in Eq 1065.642–6, and use the CFV values only up to the highest r associated with the remaining $C_{d.}$

(8) If the standard deviation of the remaining C_d still exceeds 0.3% of the mean of the remaining C_d values, repeat the steps in paragraph (e)(4) through (8) of this section.

[70 FR 40516, July 13, 2005, as amended at 73 FR 37326, June 30, 2008; 73 FR 59331, Oct. 8, 2008; 75 FR 23045, Apr. 30, 2010; 75 FR 68464, Nov. 8, 2010; 76 FR 57455, Sept. 15, 2011]

§ 1065.642 SSV, CFV, and PDP molar flow rate calculations.

This section describes the equations for calculating molar flow rates from various flow meters. After you calibrate a flow meter according to § 1065.640, use the calculations described in this section to calculate flow during an emission test.

(a) *PDP molar flow rate.* Based upon the speed at which you operate the PDP for a test interval, select the corresponding slope, $a_{1,}$ and intercept, $a_{0,}$ as calculated in § 1065.640, to calculate molar flow rate, $\dot{n}$ as follows:

$$\dot{n} = f_{\mathrm{nPDP}} \cdot \frac{p_{\mathrm{in}} \cdot V_{\mathrm{rev}}}{R \cdot T_{\mathrm{in}}}$$

Eq. 1065.642-1

Where:

$$V_{\mathrm{rev}} = \frac{a_1}{\bar{f}_{\mathrm{nPDP}}} \cdot \sqrt{\frac{p_{\mathrm{out}} - p_{\mathrm{in}}}{p_{\mathrm{out}}}} + a_0$$

Eq. 1065.642-2

Example:

a_1 = 50.43 (m³/min) = 0.8405 (m³/s)
$\bar{f}_{\mathrm{nPDP}}$ = 755.0 r/min = 12.58 r/s
p_{out} = 99950 Pa
p_{in} = 98575 Pa
a_0 = 0.056 (m³/r)
R = 8.314472 J/(mol·K)
T_{in} = 323.5 K
C_{p} = 1000 (J/m³)/kPa
C_{t} = 60 s/min

$$V_{\mathrm{rev}} = \frac{0.8405}{12.58} \cdot \sqrt{\frac{99950 - 98575}{99950}} + 0.056$$

V_{rev} = 0.06383 m³/r

$$\dot{n} = 12.58 \cdot \frac{98575 \cdot 0.06383}{8.314472 \cdot 323.5}$$

$\bar{\dot{n}}$ = 29.428 mol/s

(b) *SSV molar flow rate.* Based on the C_{d} versus $Re^{\#}$ equation you determined according to §1065.640, calculate SSV molar flow rate, $\dot{n}$ during an emission test as follows:

$$\dot{n} = C_{\mathrm{d}} \cdot C_{\mathrm{f}} \cdot \frac{A_{\mathrm{t}} \cdot p_{\mathrm{in}}}{\sqrt{Z \cdot M_{\mathrm{mix}} \cdot R \cdot T_{\mathrm{in}}}} \qquad \text{Eq. 1065.642-3}$$

Example:

A_{t} = 0.01824 m²
p_{in} = 99132 Pa
Z = 1
M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K)
T_{in} = 298.15 K
$Re^{\#}$ = $7.232 \cdot 10^5$
γ = 1.399
β = 0.8
Δp = 2.312 kPa
Using Eq. 1065.640–7,
r_{ssv} = 0.997

Using Eq. 1065.640–6,
C_f = 0.274

Using Eq. 1065.640–5,
C_d = 0.990

$$\dot{n} = 0.990 \cdot 0.274 \cdot \frac{0.01824 \cdot 99132}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 298.15}}$$

$\dot{n}$ = 58.173 mol/s

(c) *CFV molar flow rate.* Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. If you use multiple venturis and you calibrated each venturi independently to determine a separate discharge coefficient, C_d, for each venturi, calculate the individual molar flow rates through each venturi and sum all their flow rates to determine $\dot{n}$. If you use multiple venturis and you calibrated each combination of venturis, calculate $\dot{n}$ as using the sum of the active venturi throat areas as A_t, the square root of the sum of the squares of the active venturi throat diameters as d_t, and the ratio of the venturi throat to inlet diameters as the ratio of the square root of the sum of the active venturi throat diameters, d_t, to the diameter of the common entrance to all of the venturis, D. To calculate the molar flow rate through one venturi or one combination of venturis, use its respective mean C_d and other constants you determined according to §1065.640 and calculate its molar flow rate $\dot{n}$ during an emission test, as follows:

$$\dot{n} = C_d \cdot C_f \cdot \frac{A_t \cdot p_{in}}{\sqrt{Z \cdot M_{mix} \cdot R \cdot T_{in}}} \qquad \text{Eq. 1065.642-4}$$

Example:
C_d = 0.985
C_f = 0.7219
A_t = 0.00456 m²
p_{in} = 98836 Pa
Z = 1
M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K)
T_{in} = 378.15 K

$$\dot{n} = 0.985 \cdot 0.7219 \cdot \frac{0.00456 \cdot 98836}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 378.15}}$$

$\dot{n}$ = 33.690 mol/s

[75 FR 23047, Apr. 30, 2010, as amended at 75 FR 68464, Nov. 8, 2010; 76 FR 57456, Sept. 15, 2011]

§ 1065.644 Vacuum-decay leak rate.

This section describes how to calculate the leak rate of a vacuum-decay leak verification, which is described in §1065.345(e). Use Eq. 1065.644–1 to calculate the leak rate, $\dot{n}_{leak}$, and compare it to the criterion specified in §1065.345(e).

$$\dot{n}_{leak} = \frac{V_{vac}}{R} \cdot \frac{\left(\frac{p_2}{T_2} - \frac{p_1}{T_1}\right)}{(t_2 - t_1)} \qquad \text{Eq. 1065.644-1}$$

Where:

V_{vac} = geometric volume of the vacuum-side of the sampling system.

R = molar gas constant.